High-End-Developments within the Framework of Dynamic-endoscopic Viewing of Models

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Abstract
As far back as the seventies the first experiences with endoscopic viewing of models were made in the field of architecture and urban construction by introducing an endoscope into the model of the planned architectural and urban space. The monitor shows an approximation of real view of the new portion of building or city, resp. The endoscopic picture provides the viewer with the usual height of viewing and roughly the perspective of a pedestrian, whereas very often planning models of houses and city quarters are evaluated predominantly by means of the bird's eye view. Meanwhile, mechanical installations of relatively limited means have been installed at several university sites making for a simulation of spatial experience by means of endoscopic rides through a construction model such as from the view of a car driver. This paper presents a sketch for a research proposal which is aimed at anticipating high-end-developments based on the experience acquired so far using low-cost-simulations.

Survey on Simulation Techniques

In 1993 a survey titled "Fields of Application of Simulation Techniques" was performed by the author, which also supplied unique data regarding architectural endoscopy. When stock-taking the first question arising is which equipment is available for the various tasks in the field of endoscopy resp., spatial simulation and which of the available is really being put to use. The inquiry regarding the combined use and the integration resp., of simulation techniques was particularly aimed at the specific requirements in the architectural field. The questionnaire thus attempted to determine the state of the art in the field of spatial simulation empirically while compiling unique data enabling cross-connections for evaluation purposes. The investigation only included users in the academic area, a majority of those questioned being members working in a branch of a scientific organization dealing with simulation.

The question as to which combinations between simulation techniques were missing listed animation (simulation of motion), multi- and hypermedia, real picture simulation (overlapping of computer-aided and endoscopic simulations with real pictures and film sequences resp.). All of the specified combinations would have to be considered accordingly in the case of future research work. As for endoscopy also pragmatic arguments in favor thereof such as availability, simpleness and expense-profit ratio were issued. This technique also bears the great advantage that e.g. "traditional" working models can be used immediately and that training of improved spatial imaginative power is promoted. The endoscopic image is obtained rapidly and supports an interactive mode of working (representing, checking, improving, etc.) providing a relatively high level of reality. Even in complex architectural modelling the production of a *low-cost* video film by means of endoscopy may prove useful.

The question "Which developments and improvements resp. seem desirable for the future regarding the various simulation techniques?" was related to the considerations as to medium-term developments. The endoscopic spatial simulation as such seems increasingly to be being replaced by other simulation techniques. More and more users are convinced that scale models are only produced for the purpose of presentation. Great interest, however, has arisen for the developments of light-intense rigid endoscopes with simultaneous improvement of the image. This optical improvement will also enhance the combination of stereoscopy and endoscopy. The process of miniaturizing of the camera periphery is surely not over with. Further developments are to be expected towards a computer-controlled control of animation (including the number of degrees of freedom and coping of terrain jumps). The mixture of endoscopic exposure techniques with computer simulation and with real image fading over resp., will gain in importance.

Definition of Specific Lines of Research

On account of the findings of the survey on simulation techniques the following items of interest were selected and subjected to careful studies. Finally, four intended lines of research are determined as follows:

A. Connection to Peripheral Media (High-end Transmission)

Individual viewing through the ocular does not require a periphery-device, as only one person can look at the circular picture. As soon as the spatial impressions are to be stored in a medium (e.g. connecting a video-camera to the ocular) more costs are involved. The inconsistency in use of endoscopy in architecture and urban construction is mainly due to the mediocre picture quality in transmission by the peripheral equipment. The picture quality is satisfactory when viewing an architectural model by means of endoscope. The mental impression received is not easily conveyed. Improvements in communication are attempted by connecting the endoscope with peripheral recording media.

Line of Research "High-resolution and Stereo-endoscopy"

The field of *endo-photography* has been covered by careful research work (Markelin-Fahle, 1979). The development of CCD-camera technology since the eighties has only been partly registered. A further field of research deals with endoscopic optics. The development of light-intense rigid endoscopes resulting in improved image seems very interesting. These optical advancements will make for a connection of stereoscopy and endoscopy as an effective stereoscopic representation calls for extremely high resolution granting depth of field.

The problem of mediocre quality in picture transmission could be coped with 3-CCD-cameras. These make a recording technology being considerably less light sensitive and less susceptible to sudden light fluctuations. The connection of endoscope and CCD-camera is rather problematic and will require specified test series with precise measurements. Instead of the ocular a small opening is used being significantly smaller than conventional camera optics.

Simultaneous vision with both eyes is the prerequisite for 3D-perception. Both monocular visual impressions are united to a joint perception. Fusion processes result in binocular single vision. Fusion impulses emerging from the object unconsciously lead to the adjustment of fixation lines of both eyes to the object. A technical 3D-video-system will thus have to transmit two images displaced to each other to the two eyes. Therefore, the pictures are to be taken separately and subjected to further processing. In line with this the stereo-endoscope comprises two optical systems transmitting two different video-images via a double-camera. In a "Viewing Box" the single-pictures are transferred to the monitor and are superpositioned by means of an optical system. Thus both eyes receive an authentic spatial impression. Several patents (e.g. US 5381784 - Stereoscopic Endoscope / US 4926257 - Stereoscopic Electronic Endoscope Device) have been registered, ready-to-use installations, however, still are in the prototype stage and mainly concern medical applications (e.g. Storz on the occasion of the 2nd EAEA-Conference '95).

B. Control of Motion Sequences (High-end Animation)
The control of motion sequences principally involves two problematic issues. A dynamic shadow is cast if the endoscope is mounted with its camera periphery while the model is moved on a "trick table". This rather unnatural shadow cast is due to the fact that the required lighting elements are mounted and the endoscope with periphery and mounting casts a shadow. Therefore there is a preference for mounting the model to be viewed and moving the endoscope with its camera periphery. Then, however, the vibrationless drive of the endoscope becomes the issue.

A *camera rig* is a bogie wagon moved on horizontal static rails. The endoscope with its mounted camera-periphery is suspended from this bogie wagon, electricity and video signal communication being supplied by continuity contacts. A remote control turns the endoscope by 360° round its center and moves it from left to right on the bogie wagon while the bridge is driven laterally on the static rails. Thus every part of the model becomes accessible and can be viewed from every side. The device also controls the endoscope drive at the respective height (eye position) and speed. Adjustments of degrees of freedom make for a drive "straight ahead" with an angle of view from the side. Tracers can be implemented to react to possible jumps in terrain. A such equipped camera rig makes for exploring a model in a certain mode (as a pedestrian, cyclist, car driver, etc.). Mechanical plants of own make presently have been mainly in use (UCLA Berkeley, TU Delft, University Essen, University Stuttgart, TKK Tampere, etc.).

Line of Research "Robotized Camera Rig"
Robotized camera rigs have been so far neglected regarding research work. An installation using industrial robot components being assembled after adequate adaptations into a plant is characterized by a significantly higher degree of manoeuvrability during model drives. Computer-assisted control makes for programming of motion sequences.

This item will call for more involvement and personnel resources than the concentration on high-resolution video-endoscopy. Experience in the fields of machine construction and information technology will prove very useful in this respect. Based on the traditional concept of a mechanical camera rig investigations aimed at determining how industrial robotized components can be adapted for the purpose of animated endoscopy considering the design- and planning work with construction models will be required. An installation with six degrees of freedom nearly matches human perception. The precise control of driving speed should be combined with the development of a computer-assisted animation control. This means that one ride can be repeated as often as desired by means of program storage. The development of such an interface is completely new. The future group of users, however, should not only include experienced computer experts, but also untrained users, this accounting for the fact that the use of endoscopy does not require years of intensive training. Faulty programming leading to a (punctual) destruction of model and/or endoscope is to be avoided by all means.

C. Computer-assisted Image Processing (Real Image Mixing)
Computer and endoscope serve as supplements for each other. The popular mixing of endoscopic recording processes with image processing techniques demonstrates this clearly. Scanned-in masters and photo-CD's act as secondary sources of images. When connecting the endoscope with peripheral media digitizing of the recorded endo-picture is to be

accounted for. A computer plant with image processing software can be equipped with the appropriate digitizing hardware for this end. Such hardware can process e.g. PAL- or NTSC-video signals in the computer. Provided only single stills are to be stored relatively simple and inexpensive means will prove sufficient. As far as animated pictures are concerned the computer-assisted recording and editing of endoscopic sequences seem rather limited for the time being as an enormous data transfer (I/O-rate) is required despite compressing processes.

Line of Research "Bluebox- and Mapping-Processes"

Detailed models of physical nature normally are pretty costly. Moreover, "empty", rough mass models can only be used throughout a short period of the planning project for preliminary decisions. Therefore, nowadays supplementations of e.g. urban artefacts are mainly implemented and the unit is to be integrated precisely into the real existing surroundings (Thomas, 1987). The bluebox-technique (chroma-key-process) positions objects having been shot with a specific blue color in front of a background subsequently in front of a different "scenery" (real image). This video-trick-mixing is everyday use on TV, in the field of model simulation, however, it is rather rare. Human figures in motion can be shown in simulated environments with this technique. A similar performance using computer animation would cause unduly high expenses. Visualized design details and contexts such as color, texture, material are to be regarded as significant simulation details. They can be taken from a digital library and be "pasted" on the surface in their appropriate scaling (e.g. Breen/ Stellingwerff on the occasion of the 2nd EAEA-Conference '95).

Integration of model simulation in the real image calls for profound knowledge in photogrammetry, particularly when a high degree of accuracy is desired. Therefore it is necessary to collect any relevant experience and to investigate in which way a digital library with various categories of artefacts could be compiled. It has already been pointed out that physical models with a great variety of details will result in lots of work. By using mapping processes e.g. the facade structures of endoscopic mass models could be provided. What is not clear is how more exhaustive data quantities could be handled in large city models.

D. Validity- and Impact Research (Evaluation)

The point is to what extent the product of simulation as such may mutate to be the message. How is the message presented? Or: is the wrapping itself regarded as the message. We may be running the risk that the substance is not being conveyed at all and the wrapping, as it were, is not even opened. Therefore, the intrinsic effects of the simulation techniques implemented are to be dealt with. Environmental psychologists specializing in architectural psychology offer "user needs' assessments" and "post occupancy evaluations" enhancing communication between users and experts. To compare the efficiency of building walkthroughs, regular plans, simulation, and direct, long-time exposition, evaluation has to be evaluated. The provocative question may be put to what extent communication problems in architectural representation and -instruction may be traced back to the simulation technique put to use or to the unawareness of the user. Very often techniques are only used for the purpose of illustration, i.e. after completion of design work and not as a checking device during the architectural design work. Tools have to be combined with one another and be at hand, quick alterations should be feasible without problems. Not the medium is to determine the decision.

Line of Research "Accompanying Impact Research"

Computer visualizations and virtual realities grow more important, but studies on the effects of simulation techniques upon experts and users are rare (Grund, 1979; Hardie, 1988). In 1995 a user comparison of endoscopic versus CAD-simulations of a Vienna city project was realized in the framework of a joint research between the Institute for Psychology at Salzburg University (Alexander Keul) and the Department for Spatial Simulation at Vienna University of Technology on the ocaasion of the EAEA-Aspern-Workshop. A digital Aspern-model was configured as a referential object. Based on these digital data a 1:500 city model was produced in block-design. The respective heights of storeys were additionally specified by means of the building-up structure. As it principally was not to be an evaluation of the Aspern-project far-reaching details within the model were not shown (trees, persons, vehicles, facade features, etc.). Finally, an endoscopic and computer-aided picture of the main street corridor and an accompanying overall view was made. The experiment showed that - counter-intuitive to expert opinions - framing and distraction were prominent both for experts and lay people. A position effect (assessment interaction of CAD and endoscopy) was present with experts and non-experts, too. With empirical evidence for "the medium is the message", a more cautious attitude has to be adopted towards simulation products as powerful framing (i.e. perception- and opinion-shaping) devices.

Each of the aforementioned topics is to be accompanied by evaluation studies. The scope of the comparison study on Aspern (Keul-Martens, 1995) was limited: no multimedia, no photo-realism, no animation was used. Further research will be directed to these aspects on both sides. Where does the endoscopic model drive accomplished by a robotized plant range in comparison to a professional computer-assisted animation? How is the real image fade-in accepted? Which use for the planning process can be accounted for regarding implementation of stereo-endoscopy? The possibilities and limits of architectural endoscopy in a broader sense will be thoroughly determined and the disadvantages and advantages of joint use of endoscopy and additional simulation will be dealt with in more detail. Cultural and subcultural value systems of simulation technology are important for people and should be considered in evaluations. Economically, architectural simulation methods are an innovative product. To develop successful and socially useful marketing strategies, target group-specific user research is necessary. Simulations suited for architects could be bad ones for lay-people, and vice-versa. Evaluation research tips the scales in that respect.

Conclusions

Though 3D-computer simulations are presently in fashion the short training time for getting acquainted with endoscopy is still striking. The evidently great availability of *low-end-endoscopy-facilities* proves particularly useful. Concerning endoscopic viewing physical models with very differing degrees of detailing seem suited. Apart from insignificant adjustments of models the quick and uncomplicated implementation possibilities without “strings attached” are to be stressed. Thus endoscopy proves meaningful already at an early stage of design.

A *robotized camera rig* would furnish considerably more authentic motional sequences; therefore, a suited computer-controlled installation based on industrial components is to be developed within the course of this research project. Furthermore, an effective implementation of *high-resolution video-endoscopy (CCD-recording technology)* is to be achieved. Developments within the related *Bluebox- and Mapping-Processes* would lead to a first full-scope elaboration of the entire field of real picture simulation. *Stereo-endoscopy* in architectural planning is also to be regarded as unexplored territory. Three-dimensional aspects of spatial planning could be conveyed very impressingly by means of stereoscopic representation. The *accompanying impact research* is to be implemented throughout all project stages as a control instrument.

This contribution being a rough sketch for a research proposal makes any reactions very welcome, as no claims of completeness have been asserted. Possibly some aspects have not been duly considered and other developments might have been achieved a long time ago. Specific research might have already been performed in this field, but disappeared in the "grey literature". Last, but not least, the possible usefulness of scheduling the procedure into phases is to be considered, as well as the great advantages resulting from participation of several EAEA-sites.

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